(19) JAPANESE PATENT OFFICE

PATENT ABSTRACTS OF JAPAN

(11) Publication number: **10012916 A**

(43) Date of publication of application: **16.01.98**

(51) Int. Cl **H01L 33/00**

(21) Application number: **08164816**

(22) Date of filing: **25.06.96**

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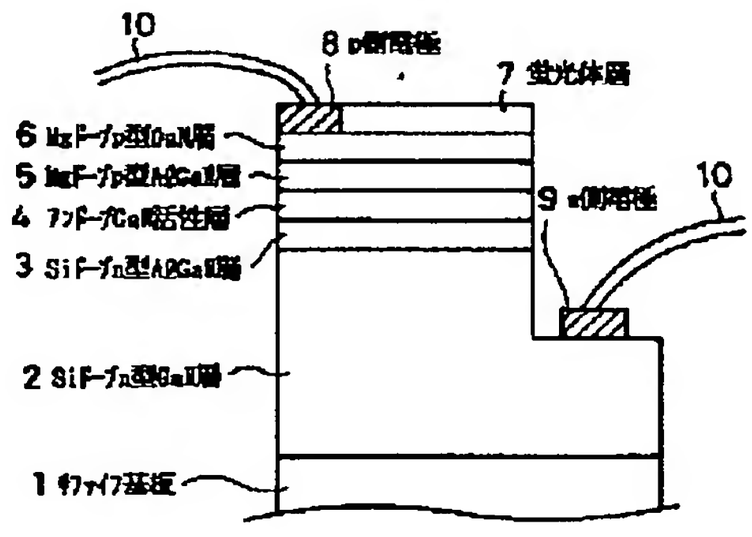
KUMA SHOJI

(54) LIGHT-EMITTING ELEMENT

(57) Abstract:

PROBLEM TO BE SOLVED: To organically connect an LED(light-emitting diode) and a phosphor and to give various hues containing white and intermediate colors while making active use of small-size, light-weight, low power consumption and long life, which are the advantages of LED.

SOLUTION: GaN material layers 2-6 are stacked on a sapphire substrate 1. A part of a crystal surface is dug to the n-type GaN layer 2. An n-side electrode 9 is formed on the n-type GaN layer 2 and a p-side electrode 8 on a p-type GaN layer 6 so as to form a GaN LED with DH(double hetero) structure outputting ultraviolet rays light. A phosphor layer 7, Y_2O_3: Eu^{3+}, for example, is applied to GaN system LED. A mask is patterned on the layer, ultraviolet rays are exposed, only a part to be left as the phosphor layer 7 is solidified, and an unnecessary part is removed. Orange light spectrum whose peak wavelength is 611nm is obtained in the light-emitting spectrum of the obtained light- emitting element.



JP 10-012916 A

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(57)Abstract:
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CLAIMS

[Claim(s)]
[Claim 1] The light emitting device characterized by carrying out the laminating of the fluorescent substance which is excited by luminescence of this light emitting diode by the front face which takes out the light of the chip of a light emitting diode, and emits fluorescence.
[Claim 2] The light emitting device characterized by carrying out the laminating of the layer containing the fluorescent substance which is excited by luminescence of this light emitting diode by the front face which takes out the light of the chip of a light emitting diode, and emits fluorescence.
[Claim 3] The light emitting device characterized by mixing with said fluorescent substance two or more kinds of fluorescent substances which have a different luminescence peak, and using them for it in a light emitting device according to claim 1 or 2.
[Claim 4] The light emitting device characterized by forming an electrode in the front face of the layer which the layer containing said fluorescent substance or fluorescent substance has conductivity in a light emitting device according to claim 1 to 3, and contains this fluorescent substance or a fluorescent substance.

[Claim 5] Setting to a light emitting device according to claim 1 to 4, light emitting diode is III. Light emitting device characterized,by being constituted by the ingredient of a group nitride system and emitting light in ultraviolet rays as an excitation light.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the light emitting device which enabled it to emit light in various colors, combining light emitting diode and a fluorescent substance organically.
[0002]
[Description of the Prior Art]Conventionally, light emitting diode (LED) is well used for the light light emitting device for a display. With the ingredient which uses LED for a luminous layer, luminescence wavelength is decided and the sharp homogeneous light of an emission spectrum is acquired. It was - **-like [LED currently used conventionally / the red LED of an A1GaAs system, and green LED of a GaP system], and blue LED of a GaN system joined this recently, and the full color display according [the three primary colors of red, blue, and a green light] to a set and LED was attained.
[0003]The luminescence device using a fluorescent substance is used as what, on the other hand, obtains luminescence of various colors, and white and neutral colors. The fluorescent lamp which made the ultraviolet rays emitted by low voltage mercury discharge the excitation light source is widely used for the luminescence device using a fluorescent substance.
[0004]
[Problem(s) to be Solved by the Invention]LED needed to be used combining LED created by different ingredient system, in order to obtain luminescence of various colors, and white and neutral colors, since luminescence wavelength was decided for every ingredient as mentioned above and only the homogeneous light is acquired, while there are small, a light weight, a low power, and an advantage of being long lasting. However, since the listing device and process unit of a crystal which are different for every ingredient system in order to create LED of a different ingredient system were needed, great costs, an effort, time amount,

and a technique needed to be accumulated.
[0005]Moreover, in order to take out white and neutral colors with one LED, the chip which consists of an ingredient with which plurality differs needed to be carried in one LED, and when there was a problem of if the structure of LED is complicated, manufacture is difficult, therefore it is expensive or fine tuning of a tint is difficult, the drive circuit had to be changed for every property of LED. For this reason, LED is unsuitable for an application which needs white and one kind of neutral colors, and was used for it until now only at the display of primary lights.
[0006]Although there was no fault like the light emitting diode mentioned above from delicate adjustment of a tint being possible with this point because a fluorescent lamp changes the class of fluorescent substance, since the discharge tube was required, there was a problem that the power circuit for lighting was required, difficultly [a miniaturization]. Moreover, there was also a problem that a life was short compared with LED.
[0007]The purpose of this invention is to cancel the trouble of the conventional technique mentioned above and offer the light emitting device which can give off the light of various tints which were easy structure, and were not made until now, harnessing the advantage of LED.
[0008]
[Means for Solving the Problem]Invention according to claim 1 is a light emitting device characterized by carrying out the laminating of the fluorescent substance which is excited by luminescence of this light emitting diode by the front face which takes out the light of the chip of a light emitting diode, and emits fluorescence.
[0009]What emits the fluorescence of desired wavelength is chosen and used for a fluorescent substance by making luminescence of LED into excitation light. If this excites a fluorescent substance by luminescence of LED, the light of the luminescent color of light emitting diode and the different luminescent color can be given off. Therefore, the light emitting device of various tints which are not obtained can be obtained at LED with the easy structure where it is only to change the fluorescent substance which carries out a laminating to a chip front face, without changing the class of LED, i.e., an ingredient. Moreover, an excitation beam of light can be efficiently used by carrying out the direct laminating of the fluorescent substance on an LED chip.
[0010]As the excitation light source of a fluorescent substance, there are an X-ray, an electron ray, ultraviolet - a visible ray, etc. In this invention, the ultraviolet rays emitted by LED - a visible ray are used as an excitation light. The fluorescent substance which is excited by ultraviolet rays and emits the light on the ultraviolet-rays luminescence LED created especially using the GaN system crystal, For example, Y2 O3 : Eu (luminescent color: red) and 3 (Sr, Mg, Ba) 2 (Po4) (luminescent color: sour orange), ZnS:Cu (luminescent color: green), 3Sr3 2 (Po4) and CaCl2Eu2+ (luminescent color: blue), halo phosphate system fluorescent substance : (by changing the ratio of F and Cl in Sb3+ of an activator, Mn2+, and a parent)the laminating of it being possible to change until blue white - ** white etc. is carried out, and it uses. Moreover, the well-known fluorescent substance which emits fluorescence colors other than these can also be used.
[0011]Invention according to claim 2 is a light emitting device characterized by carrying out the laminating of the layer containing the fluorescent substance which is excited by luminescence of this light emitting diode by the front face which takes out the light of the chip of a light emitting diode, and emits fluorescence. Since it becomes possible to carry out the laminating of the fluorescent substance content layer using the crystal production process of light emitting diode, and the same process in carrying out the laminating of the layer containing a fluorescent substance rather than carrying out the laminating of the fluorescent substance to a direct chip side, simplification of a production process can be attained.
[0012]Invention according to claim 3 is a light emitting device characterized by

mixing with said fluorescent substance two or more kinds of fluorescent substances which have a different luminescence peak, and using them for it in a light emitting device according to claim 1 or 2. If two or more kinds of fluorescent substances which have a different luminescence peak are mixed and are used, light with two or more luminescence peaks can be given off, and neutral colors will also be obtained easily.

[0013]Invention according to claim 4 is a light emitting device characterized by forming an electrode in the front face of a layer on which the layer containing said fluorescent substance or fluorescent substance has conductivity, and contains this fluorescent substance or a fluorescent substance in a light emitting device according to claim 1 to 3. When an electrode is formed on a fluorescent substance using a fluorescent substance with conductivity, luminescence can be efficiently obtained by energizing to LED through a fluorescent substance, without deleting the luminescence area of a fluorescent substance with an electrode.

[0014]Setting invention according to claim 5 to a light emitting device according to claim 1 to 4, light emitting diode is III. It is the light emitting device characterized by being constituted by the ingredient of a group nitride system and emitting light in ultraviolet rays as an excitation light. III which emits light in ultraviolet rays When the light emitting diode which consisted of ingredients of a group nitride system is used, the luminous efficiency of a fluorescent substance becomes good.

[0015]

[Embodiment of the Invention]The gestalt of operation of this invention is explained using a drawing below. Drawing 1 is structural drawing of the light emitting device by the gestalt of this operation.

[0016]In order to produce this light emitting device, first, metal-organic chemical vapor deposition (MOVPE law) is used on silicon on sapphire 1, and the laminating of the Si dope n mold GaN layer 2, the Si dope n mold AlGaN layer 3, the undoping GaN layer 4, the Mg dope p mold AlGaN layer 5, and the Mg dope p mold GaN layer 6 is carried out to this order. The crystal which carries out a laminating adds heat treatment in nitrogen-gas-atmosphere mind in order to make Mg dope layers 5 and 6 form into p mold. In addition, it is well-known, for example, the technique which carries out the laminating of these GaN(s) system ingredient, grows, and creates LED is Appl.Physics. Letter 64 (13), 1994, pp1687-1689ya, J.Crystal Growth It is indicated in detail by 145(1994) pp 911-917 etc.

[0017]If a part of crystal front face is investigated until it reaches the n mold GaN layer 2 by etching, and the p lateral electrode 8 is formed [in the phase where added heat treatment and Mg dope layers 5 and 6 were made to form into p mold,] on the n mold GaN layer 2, respectively on the n lateral electrode 9 and the p mold GaN layer 6, the GaN system LED of DH (double hetero) structure will be made. In this way, if bonding of the wire 10 is carried out and it is energized to the electrodes 8 and 9 of created LED, luminescence corresponding to the band structure of a barrier layer will be obtained. In the example of a gestalt of this operation, ultraviolet-rays luminescence with a peak wavelength of 360nm corresponding to the bandgap energy of GaN was obtained by having used the barrier layer as the undoping GaN layer 4. The obtained emission spectrum is shown in drawing 2.

[0018]The light emitting device which starts the gestalt of operation of this invention which emits light as an excitation light in ultraviolet-rays luminescence of this LED was produced as follows. On the GaN system LED created by the above-mentioned approach, it is fluorescent substance Y2 O3. : The powder of Eu3+ was mixed with polyvinyl alcohol, and the spin coat of what carried out minute amount ****** distribution of the dichromate was carried out. The mask pattern was covered over this, ultraviolet-rays exposure was performed, only the part to leave as a fluorescent substance layer 7 was solidified, and the unnecessary part was flushed by the organic solvent. In order to remove an unnecessary organic solvent at the end, it was made to dry in a 200-degree C

dryer. In this way, the emission spectrum of the created light emitting device is shown in drawing 3. Luminescence was a sour orange with a peak wavelength of 611nm.
[0019]With the same approach, they are 3Sr3 2 (Po4) and CaCl2 to a fluorescent substance ingredient. : The emission spectrum of the light emitting device created using Eu2+ is shown in drawing 4. The emission spectrum of this light emitting device was blue with a peak wavelength of 452nm.
[0020]Furthermore, they are 3calcium3 2 (Po4) and calcium (F, Cl)2 to a fluorescent substance ingredient with the same approach. : The emission spectrum of the light emitting device created using Sb3+ and Mn2+ is shown in drawing 5. The emission spectrum of this light emitting device had two peak wavelength, 480nm and 576nm, and was the white light.
[0021]Thus, the light emitting device of various colors can be obtained by carrying out the laminating of the different fluorescent substance ingredient on LED completely created with the same ingredient and structure.
[0022]Next, the example of structure of a light emitting device in case a fluorescent substance layer has conductivity is described using drawing 6.

[0023]Laminating growth of the GaN system ingredient layers 2-6 was carried out on the silicon on sapphire 1 for creating the ultraviolet-rays luminescence LED by the same approach as ****, heat treatment was added to this, and p type layer 6 was made to form into low resistance. Furthermore on it, the ZnS:Cu layer 17 was grown up as a fluorescent substance layer by vapor growth. Then, it investigated until it reached the n mold GaN layer 2 by etching in - section on the front face of a crystal of a crystal using the photolithography technique and the reactant gas-phase-etching (RIE) technique, and the p lateral electrode 8 was formed on the n lateral electrode 9 and the ZnS:Cu layer 17 on the n mold GaN layer 2, and the light emitting device was created. This light emitting device showed green luminescence with a peak wavelength of 530nm. Thus, when a fluorescent substance layer has conductivity, it is also possible to form an electrode 8 on a fluorescent substance layer.
[0024]By the conventional LED, the light emitting device of the tint which was not able to be realized is obtained easily, employing efficiently the advantage of small, a light weight, a low power, and LED of being long lasting, as it is, since light emitting diode and a fluorescent substance were organically combined according to the operation gestalt of this invention as stated above.

[0025]Moreover, since there is little equipment which needs for manufacture what had to change the ingredient for every luminescent color, had to arrange the LED manufacturing installation for every ingredient in order to produce the light emitting device of various colors in the former, and had to start the manufacturing technology, and it ends, since the light emitting device of various colors can be easily obtained by changing only a fluorescent substance ingredient with the same structure, and a production process can be simplified, a manufacturing cost can be reduced sharply.
[0026]Moreover, since the property of LED which gives off excitation light does not change even if it changes a fluorescent substance ingredient, an electrical property is the same and the light emitting device from which only a fluorescence color differs can be obtained easily. For this reason, in case it uses combining the component from which the luminescent color differs, conventionally, all the things that had to change the drive circuit for every property of LED can make light emit in the same drive circuit now, and simplification of a drive system can be attained.
[0027]Furthermore, since neutral colors and white are obtained easily, it is applicable also to fields, such as lighting with which LED was not used until now.
[0028]In addition, as long as the **** fluorescent substance for light emitting devices is excited by luminescence of LED and emits fluorescence, any are sufficient as it. Moreover, the ingredients (luminous paint etc.) which emit the

light which is excited by luminescence of LED and does not shine are also contained in a fluorescent substance ingredient here.
[0029]The ingredient of LED which emits excitation light, and structure are not limited to a specific thing that what is necessary is just to choose a what is the the best for excitation of fluorescent substance, for example, AlGaAs, and GaP system etc. according to the fluorescent substance to be used. However, as an excitation light of a fluorescent substance, the ultraviolet rays are more efficient and, for the moment, a GaN system ingredient is the most efficient than the light as an ingredient of LED which emits ultraviolet rays.

[0030]According to excitation luminous intensity and the rate of excitation light absorption of a fluorescent substance, the spreading thickness of a fluorescent substance should just choose an optimum value, and is not limited.
[0031]in addition -- that the fluorescent substance which carries out a laminating to an LED chip carries out the laminating only not only of the approach by spreading which was stated with the gestalt of operation but the fluorescent substance by direct vacuum evaporationo or the spatter **** -- a chip top -- SiO2 aluminum 2O3 etc. -- in case a laminating is carried out with a CVD method, the laminating of the fluorescent substance can be doped and carried out. It is also possible to prepare the film for controlling a protective coat and the rate of optical refraction in the fluorescent substance layer front face of a light emitting device.
[0032]The light emitting device concerning this invention can be used for the same application as LED conventionally used widely as a component for a display, and also it can be broadly applied even to the annunciator and floodlight of a device for which the luminescent color needs the multiple color for which LED was not used until now since the light emitting device of neutral colors is obtained.

[0033]
[Effect of the Invention]According to this invention, the light of various tints containing the white which was not able to be realized, and neutral colors can be emitted at the conventional LED with the easy structure of exciting the fluorescent substance which carried out the laminating to LED, and making it emit light by LED, employing efficiently the advantage of small, a light weight, a low power, and LED of being long lasting, as it is. Moreover, light can be emitted in various colors only by not changing the ingredient or structure of LED but changing a fluorescent substance ingredient.

DESCRIPTION OF DRAWINGS

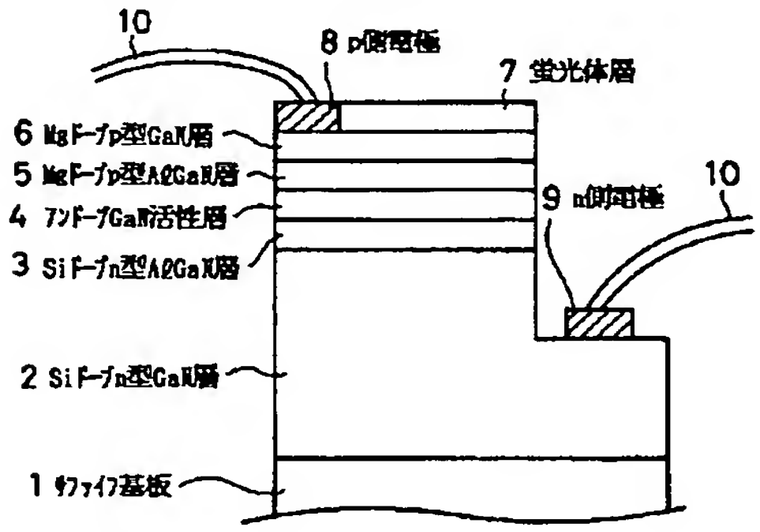
[Brief Description of the Drawings]
[Drawing 1]It is drawing showing the structure of the light emitting device concerning the example of a gestalt of operation of this invention.
[Drawing 2]It is the emission spectrum of the GaN system ultraviolet rays LED.

[Drawing 3]It is Y2 O3 to a fluorescent substance. : It is the emission spectrum of the light emitting device concerning the example of a gestalt of operation of this invention created using Eu3+.
[Drawing 4]They are 3Sr3 2 (Po4) and CaCl2 to a fluorescent substance. : It is the emission spectrum of the light emitting device concerning the example of a gestalt of operation of this invention created using Eu2+.
[Drawing 5]They are 3calcium3 2 (Po4) and calcium (F, Cl)2 to a fluorescent substance. : It is the emission spectrum of the light emitting device concerning the example of a gestalt of operation of this invention created using Sb3+ and Mn2+.
[Drawing 6]It is drawing showing the structure of the light emitting device concerning the example of a gestalt of other operations of this invention.

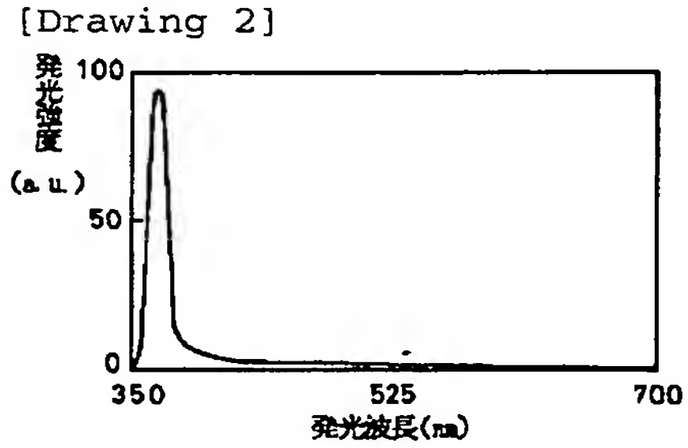
[Description of Notations]
1 Silicon on Sapphire
2 N Mold GaN Layer
3 N Mold AlGaN Layer
4 GaN Barrier Layer
5 P Mold AlGaN Layer
6 P Mold GaN Layer
7 Fluorescent Substance Layer
8 P Lateral Electrode
9 N Lateral Electrode

DRAWINGS

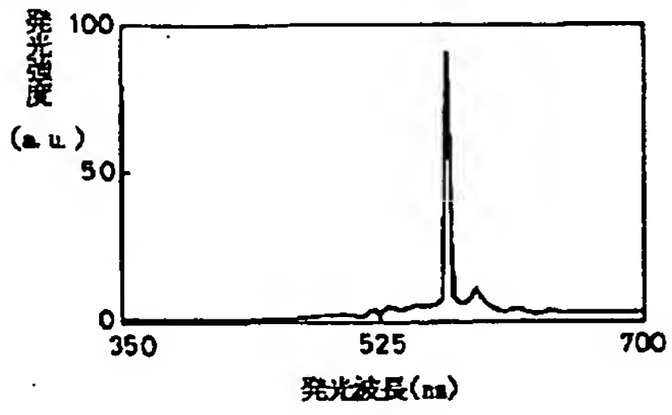
[Drawing 1]



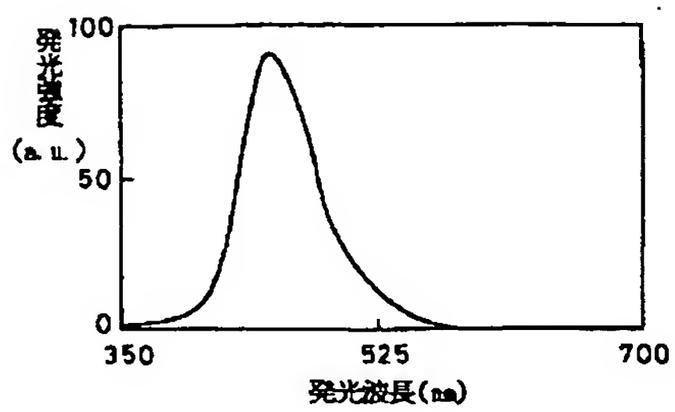
[Drawing 2]



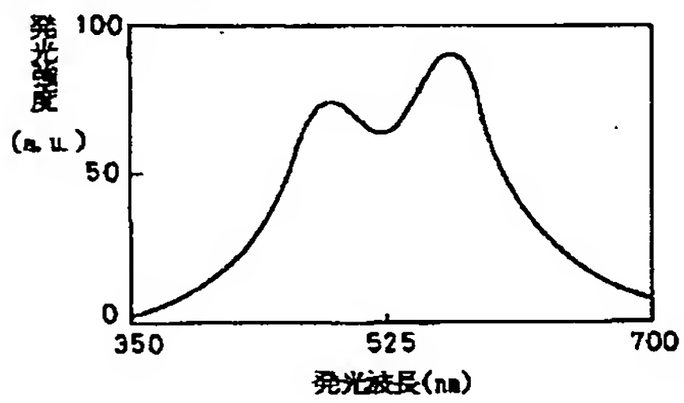
[Drawing 3]



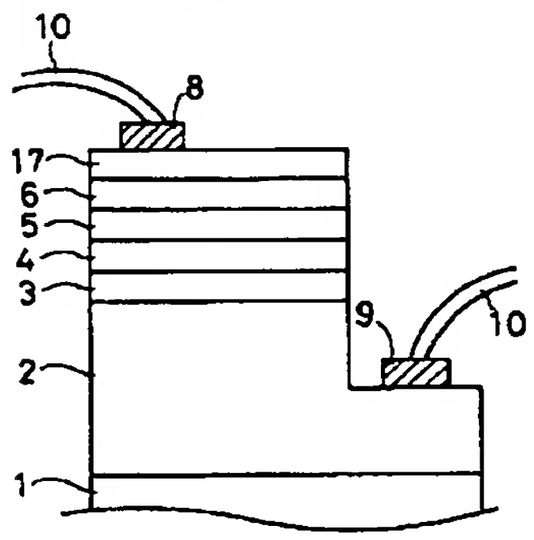
[Drawing 4]



[Drawing 5]



[Drawing 6]



(19)日本国特許庁（ＪＰ）　(12)**公開特許公報**（Ａ）　(11)特許出願公開番号

特開平10－12916

(43)公開日　平成10年(1998)１月16日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　33/00			Ｈ０１Ｌ　33/00	Ａ

審査請求　未請求　請求項の数５　ＯＬ　（全　５　頁）

(21)出願番号　特願平8－164816

(22)出願日　平成８年(1996)６月25日

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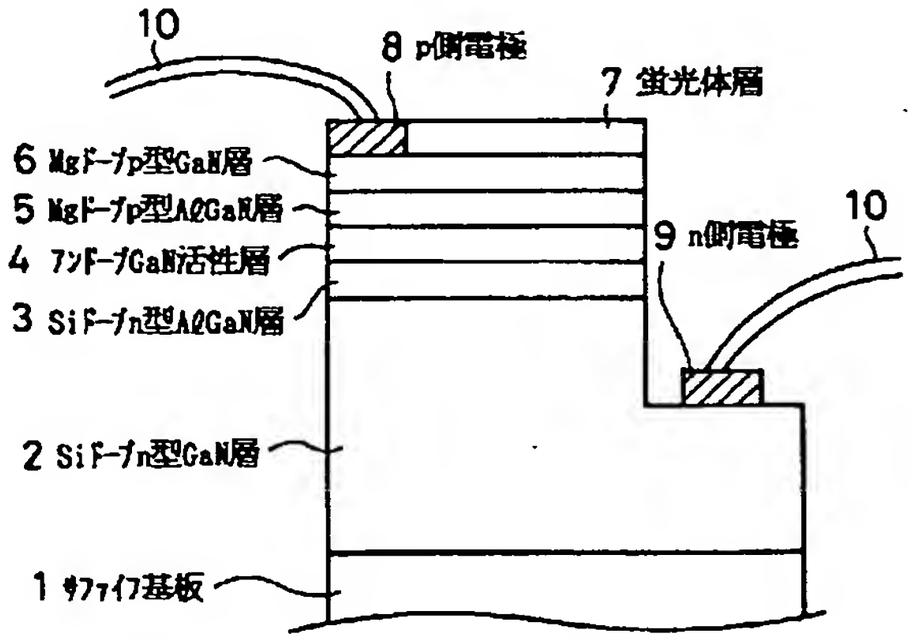
(54)【発明の名称】　発光素子

(57)【要約】
【課題】ＬＥＤと蛍光体とを有機的に結合して、ＬＥＤの長所である小型、軽量、低消費電力、長寿命といった点を活かしつつ、これまでできなかった白色、中間色を含む様々な色合いを出せるようにする。
【解決手段】サファイア基板１上にＧａＮ系材料層２～６を積層し、結晶表面の一部をｎ型ＧａＮ層２に到達するまで掘り下げ、ｎ型ＧａＮ層２の上にｎ側電極９を、そしてｐ型ＧａＮ層６上にｐ側電極８を形成して、紫外線発光を出力するＤＨ構造のＧａＮ系ＬＥＤを形成する。このＧａＮ系ＬＥＤ上に、蛍光体層７、例えばY_2O_3：Eu^{3+}を塗布する。これにマスクパターンをかけ、紫外線露光を行って、蛍光体層７として残したい部分だけを固化させ、不要な部分を除去する。得られた発光素子の発光スペクトルはピーク波長６１１nmの橙が得られる。



【特許請求の範囲】
【請求項１】発光ダイオードのチップの光を取り出す表面に、該発光ダイオードの発光により励起されて蛍光を発する蛍光体を積層したことを特徴とする発光素子。
【請求項２】発光ダイオードのチップの光を取り出す表面に、該発光ダイオードの発光により励起されて蛍光を発する蛍光体を含有する層を積層したことを特徴とする発光素子。
【請求項３】請求項１または２に記載の発光素子において、前記蛍光体に、異なる発光ピークを有する蛍光体を２種類以上混ぜて用いることを特徴とする発光素子。
【請求項４】請求項１ないし３のいずれかに記載の発光素子において、前記蛍光体または蛍光体を含有する層が導電性を有し、かつ該蛍光体または蛍光体を含有する層の表面に電極を形成したことを特徴とする発光素子。
【請求項５】請求項１ないし４のいずれかに記載の発光素子において、発光ダイオードはIII 族窒化物系の材料により構成され、励起光として紫外線を発光することを特徴とする発光素子。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、発光ダイオードと蛍光体とを有機的に組合わせて種々の色を発光できるようにした発光素子に関するものである。
【０００２】
【従来の技術】従来、表示用の可視光発光素子には、発光ダイオード（ＬＥＤ）がよく用いられている。ＬＥＤは発光層に用いる材料によって発光波長が決まり、発光スペクトルの鋭い単色光が得られる。従来使用されているＬＥＤは、Ａ１ＧａＡｓ系の赤色ＬＥＤ、ＧａＰ系の緑色ＬＥＤが一般的で、最近これにＧａＮ系の青色ＬＥＤが加わって、赤、青、緑の光の３原色が揃い、ＬＥＤによるフルカラーディスプレイが可能になった。
【０００３】一方、様々な色の発光や、白色、中間色を得るものとして、蛍光体を利用した発光機器が使用されている。蛍光体を利用した発光機器には、低圧水銀放電により放出される紫外線を励起光源とした蛍光ランプが広く利用されている。
【０００４】
【発明が解決しようとする課題】ＬＥＤは、小型、軽量、低消費電力、長寿命という利点がある反面、上述のように材料毎に発光波長が決まっており、また単色光しか得られないため、様々な色の発光や、白色、中間色を得るためには、異なる材料系で作成したＬＥＤを組み合わせて用いる必要があった。しかし、異なる材料系のＬＥＤを作成するためには、材料系毎に異なる結晶の作成装置やプロセス装置を必要とするため、多大な費用、労力、時間そして技術の蓄積が必要であった。
【０００５】また、１つのＬＥＤで白色や中間色を出すためには、１つのＬＥＤ内に複数個の異なる材料からなるチップを搭載する必要があり、ＬＥＤの構造が複雑で製作が難しく、従って高価であるとか、色合いの微調整が難しいとかといった問題がある上、ＬＥＤの特性毎に駆動回路を変えなければならなかった。このため、白色や中間色を１種類だけ必要とするような用途には、ＬＥＤは不向きであり、これまで原色光の表示にしか用いられてこなかった。
【０００６】この点で、蛍光ランプは蛍光体の種類を変えることで色合いの微妙な調整が可能であることから上述した発光ダイオードのような不具合はないが、放電管が必要なため小型化が難しく、また点灯のための電源回路が必要であるという問題があった。また、ＬＥＤに較べて寿命が短いという問題もあった。
【０００７】本発明の目的は、上述した従来技術の問題点を解消して、簡単な構造で、ＬＥＤの長所を活かしつつ、これまでできなかった様々な色合いの光を出すことが可能な発光素子を提供することにある。
【０００８】
【課題を解決するための手段】請求項１に記載の発明は、発光ダイオードのチップの光を取り出す表面に、該発光ダイオードの発光により励起されて蛍光を発する蛍光体を積層したことを特徴とする発光素子である。
【０００９】蛍光体には、ＬＥＤの発光を励起光として、所望の波長の蛍光を発するものを選択して用いる。これによりＬＥＤの発光で蛍光体を励起すると、発光ダイオードの発光色と異なる発光色の光を出すことができる。したがって、ＬＥＤの種類、即ち材料を変えることなく、チップ表面に積層する蛍光体を変えるだけという簡単な構造で、ＬＥＤでは得られない様々な色合いの発光素子を得ることができる。また、蛍光体をＬＥＤチップ上に直接積層することで、励起光線を効率よく利用することができる。
【００１０】蛍光体の励起光源としては、Ｘ線、電子線、紫外～可視光線などがある。本発明では、このうちＬＥＤで発した紫外線～可視光線を励起光として用いる。特にＧａＮ系結晶を用いて作成した紫外線発光ＬＥＤ上に、紫外線で励起されて可視光を発する蛍光体、例えばY_2O_3：Ｅｕ（発光色：赤）、$(Sr, Mg, Ba)_3(PO_4)_2$（発光色：橙）、ＺｎＳ：Ｃｕ（発光色：緑）、$3Sr_3(PO_4)_2 \cdot CaCl_2$：$Eu^{2+}$（発光色：青）、ハロリン酸塩系蛍光体（付活剤の$Sb^{3+}$と$Mn^{2+}$および母体中のＦとＣｌの比率を変えることによって、青白色～温白色まで変えることが可能）などを積層して用いる。また、これら以外の蛍光色を発する公知の蛍光体も使用できる。
【００１１】請求項２に記載の発明は、発光ダイオードのチップの光を取り出す表面に、該発光ダイオードの発光により励起されて蛍光を発する蛍光体を含有する層を積層したことを特徴とする発光素子である。蛍光体を直接チップ面に積層するのではなく、蛍光体を含有する層

を積層する場合には、発光ダイオードの結晶作製工程と同様な工程を使って蛍光体含有層を積層することが可能となるので、製造工程の簡素化が図れる。

【００１２】請求項３に記載の発明は、請求項１または２に記載の発光素子において、前記蛍光体に、異なる発光ピークを有する蛍光体を２種類以上混ぜて用いることを特徴とする発光素子である。異なる発光ピークを有する蛍光体を２種類以上混ぜて用いると、複数の発光ピークを持つ光を出すことができ、中間色も容易に得られる。

【００１３】請求項４に記載の発明は、請求項１ないし３のいずれかに記載の発光素子において、前記蛍光体または蛍光体を含有する層が導電性を有し、かつ該蛍光体または蛍光体を含有する層の表面に電極を形成したことを特徴とする発光素子である。導電性のある蛍光体を用いて蛍光体上に電極を形成した場合には、蛍光体を通じてＬＥＤに通電することで、蛍光体の発光面積を電極によって削られることなく、効率よく発光を得ることができる。

【００１４】請求項５に記載の発明は、請求項１ないし４のいずれかに記載の発光素子において、発光ダイオードはIII 族窒化物系の材料により構成され、励起光として紫外線を発光することを特徴とする発光素子である。紫外線を発光するIII 族窒化物系の材料より構成された発光ダイオードを使用した場合には、蛍光体の発光効率がよくなる。

【００１５】

【発明の実施の形態】以下に本発明の実施の形態を図面を用いて説明する。図１は本実施の形態による発光素子の構造図である。

【００１６】この発光素子を作製するには、まず、サファイア基板１上に有機金属気相成長法（ＭＯＶＰＥ法）を用いて、Ｓｉドープｎ型ＧａＮ層２、Ｓｉドープｎ型ＡｌＧａＮ層３、アンドープＧａＮ層４、Ｍｇドープｐ型ＡｌＧａＮ層５、Ｍｇドープｐ型ＧａＮ層６をこの順に積層する。積層する結晶は、Ｍｇドープ層５、６をｐ型化させるために、窒素雰囲気中で熱処理を加える。なお、これらＧａＮ系材料を積層して成長し、ＬＥＤを作成する技術は公知であり、例えばＡｐｐｌ．Ｐｈｙｓｉｃｓ　Ｌｅｔｔｅｒ　６４（１３），１９９４，ｐｐ１６８７－１６８９ｙａ，Ｊ．Ｃｒｙｓｔａｌ　Ｇｒｏｗｔｈ　１４５（１９９４）ｐｐ９１１－９１７などに詳しく開示されている。

【００１７】熱処理を加えてＭｇドープ層５、６をｐ型化させた段階で、結晶表面の一部をエッチングによりｎ型ＧａＮ層２に到達するまで掘り下げ、ｎ型ＧａＮ層２の上にｎ側電極９を、そしてｐ型ＧａＮ層６上にｐ側電極８をそれぞれ形成すると、ＤＨ（ダブルヘテロ）構造のＧａＮ系ＬＥＤができる。こうして作成したＬＥＤの電極８、９にワイヤ１０をボンディングして通電すると、活性層のバンド構造に対応した発光が得られる。本実施の形態例では、活性層をアンドープＧａＮ層４としたことで、ＧａＮのバンドギャップエネルギーに対応した、ピーク波長３６０nmの紫外線発光が得られた。得られた発光スペクトルを図２に示す。

【００１８】このＬＥＤの紫外線発光を励起光として発光する本発明の実施の形態にかかる発光素子を、次のようにして作製した。上述の方法で作成したＧａＮ系ＬＥＤ上に、蛍光体Y_2O_3：Eu^{3+}の粉末をポリビニルアルコールに混ぜ、重クロム酸塩を微量混ぜて分散させたものをスピンコートした。これにマスクパターンをかけ、紫外線露光を行って、蛍光体層７として残したい部分だけを固化させ、不要な部分を有機溶剤で洗い流した。最後に、不要な有機溶剤を除去するため、２００℃の乾燥機中で乾燥させた。こうして作成した発光素子の発光スペクトルを図３に示す。発光はピーク波長６１１nmの橙であった。

【００１９】同様の方法で、蛍光体材料に$3Sr_3(PO_4)_2 \cdot CaCl_2$：$Eu^{2+}$を用いて作成した発光素子の発光スペクトルを図４に示す。この発光素子の発光スペクトルは、ピーク波長４５２nmの青色であった。

【００２０】さらに、同様の方法で、蛍光体材料に$3Ca_3(PO_4)_2 \cdot Ca(F,Cl)_2$：$Sb^{3+}$，$Mn^{2+}$を用いて作成した発光素子の発光スペクトルを図５に示す。この発光素子の発光スペクトルは、４８０nmと５７６nmの２つのピーク波長をもち、白色光であった。

【００２１】このように、まったく同一材料、構造で作成したＬＥＤ上に異なる蛍光体材料を積層することで、様々な色の発光素子を得ることができる。

【００２２】次に、蛍光体層が導電性を有する場合の発光素子の構造例を図６を用いて述べる。

【００２３】上述と同様の方法で紫外線発光ＬＥＤを作成するためのサファイア基板１上にＧａＮ系材料層２～６を積層成長させ、これに熱処理を加えてｐ型層６を低抵抗化させた。さらにその上に、気相成長法で蛍光体層としてＺｎＳ：Ｃｕ層１７を成長させた。その後、フォトリソグラフィ技術と反応性気相エッチング（ＲＩＥ）技術を用いて結晶の結晶表面の一部をエッチングによりｎ型ＧａＮ層２に到達するまで掘り下げ、ｎ型ＧａＮ層２の上にｎ側電極９を、そしてＺｎＳ：Ｃｕ層１７の上にｐ側電極８を形成して発光素子を作成した。この発光素子は、ピーク波長５３０nmの緑色発光を示した。このように蛍光体層が導電性を有する場合は、蛍光体層上に電極８を形成することも可能である。

【００２４】以上述べたように、本発明の実施形態によれば、発光ダイオードと蛍光体とを有機的に組合わせたので、小形、軽量、低消費電力、長寿命といったＬＥＤの長所をそのまま生かしながら、従来のＬＥＤでは実現できなかった色合いの発光素子が容易に得られる。

【００２５】また、同一構造で蛍光体材料だけを変える

ことにより、種々の色の発光素子を容易に得ることができるため、従来では種々の色の発光素子を作製するために、発光色毎に材料を変え、材料毎にＬＥＤ製造装置を揃えて、製造技術を立上げていかなければならなかったものが、製造に必要な装置が少なくて済み、製造工程が簡略化できるため、製造コストを大幅に低減できる。

【００２６】また、蛍光体材料を変えても励起光を出すＬＥＤの特性は変らないため、電気特性が同じで蛍光色だけが異なる発光素子を容易に得ることができる。このため、発光色の異なる素子を組合わせて使う際に、従来はＬＥＤの特性毎に駆動回路を変えなければならなかったものが、全て同じ駆動回路で発光させることができるようになり、駆動系の簡素化が図れる。

【００２７】さらに、中間色や白色が容易に得られるため、これまでＬＥＤが使われていなかった照明などの分野にも適用することができる。

【００２８】なお、発光素子用いる蛍光体は、ＬＥＤの発光により励起されて蛍光を発するものならばいずれでも良い。またＬＥＤの発光により励起されてりん光を発する材料（夜光塗料等）もここでは蛍光体材料に含まれる。

【００２９】励起光を発するＬＥＤの材料、構造は、用いる蛍光体に合わせて蛍光体の励起に最適なもの、例えばＡｌＧａＡｓ、ＧａＰ系などを選べば良く、特定のものに限定されない。ただし、蛍光体の励起光としては、可視光よりも紫外線の方が効率が良く、紫外線を発するＬＥＤの材料としては、今のところＧａＮ系材料が最も高効率である。

【００３０】蛍光体の塗布厚さは、励起光の強度、蛍光体の励起光吸収率に合わせて最適値を選べば良く、限定されるものではない。

【００３１】なお、ＬＥＤチップに積層する蛍光体は、実施の形態で述べたような塗布による方法だけでなく、蛍光体だけを直接蒸着やスパッタ法で積層したり、チップ上にSiO_2 やAl_2O_3 等をＣＶＤ法で積層する際に蛍光体をドープして積層することができる。発光素子の蛍光体層表面に、保護膜や光の屈折率を制御するための膜を設けることも可能である。

【００３２】本発明にかかる発光素子は、従来表示用素子として広く用いられているＬＥＤと同様の用途に用いることができるほか、発光色が中間色の発光素子が得られることから、これまでＬＥＤが利用されていなかった多色を必要とする機器の表示灯や照明灯にまで幅広く応用することが可能である。

【００３３】

【発明の効果】本発明によれば、ＬＥＤに積層した蛍光体をＬＥＤで励起して発光させるという簡単な構造で、小形、軽量、低消費電力、長寿命といったＬＥＤの長所をそのまま生かしながら、従来のＬＥＤでは実現できなかった白色、中間色を含む様々な色合いの光を発することができる。また、ＬＥＤの材料や構造を変えず、蛍光体材料を変えるだけで、種々の色を発光することができる。

【図面の簡単な説明】

【図１】本発明の実施の形態例にかかる発光素子の構造を示す図である。

【図２】ＧａＮ系紫外線ＬＥＤの発光スペクトルである。

【図３】蛍光体にY_2O_3：Eu^{3+}を用いて作成した本発明の実施の形態例にかかる発光素子の発光スペクトルである。

【図４】蛍光体に$3Sr_3(PO_4)_2 \cdot CaCl_2$：$Eu^{2+}$を用いて作成した本発明の実施の形態例にかかる発光素子の発光スペクトルである。

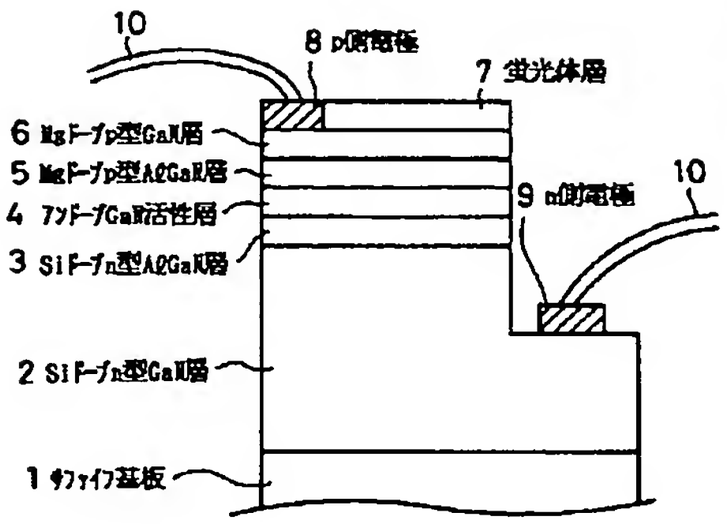
【図５】蛍光体に$3Ca_3(PO_4)_2 \cdot Ca(F,Cl)_2$：$Sb^{3+}$，$Mn^{2+}$を用いて作成した本発明の実施の形態例にかかる発光素子の発光スペクトルである。

【図６】本発明の他の実施の形態例にかかる発光素子の構造を示す図である。

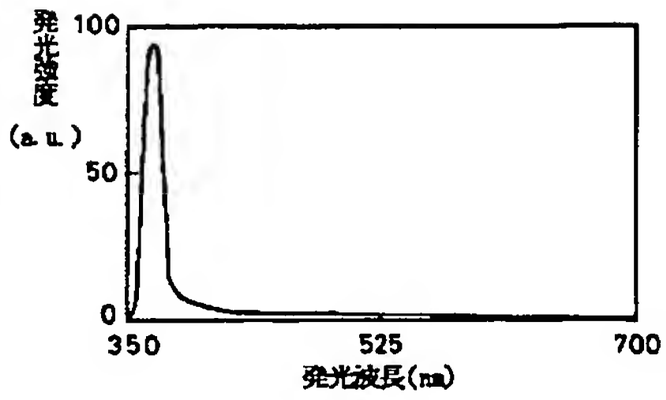
【符号の説明】

１　サファイア基板
２　ｎ型ＧａＮ層
３　ｎ型ＡｌＧａＮ層
４　ＧａＮ活性層
５　ｐ型ＡｌＧａＮ層
６　ｐ型ＧａＮ層
７　蛍光体層
８　ｐ側電極
９　ｎ側電極

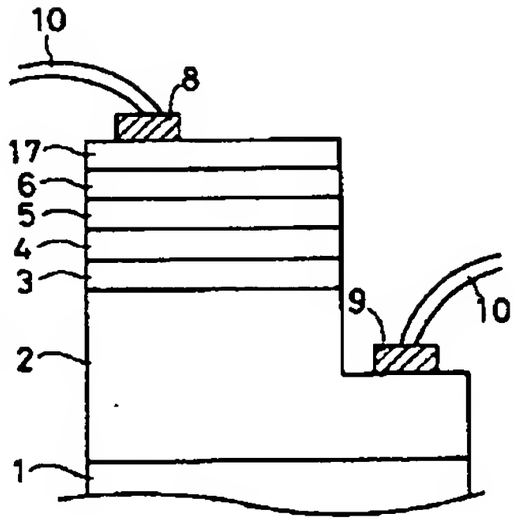
【図１】



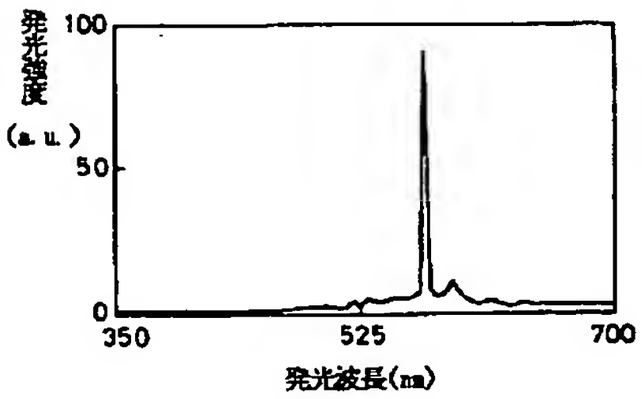
【図２】



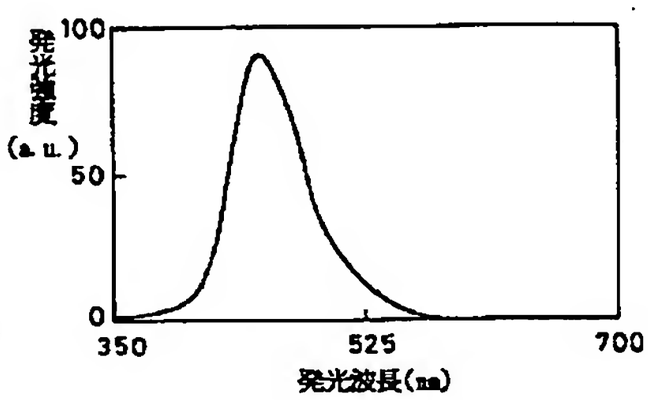
【図６】



【図３】



【図４】



【図５】